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Tunable DBR Laser for Wavelength Conversion of 2.5 Gbit/s Signals

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Objective: Demonstration of wavelength conversion of 2.5 Gbit/s signals using a tunable DBR laser as the wavelength converting element. This is to the authors' knowledge the highest bitrate used in a wavelength conversion transmission experiment. We present penalty free conversion by more than 15 nm and a signal chip-gain of 13 dB.

Background: To fully exploit the bandwidth and flexibility of wavelength division multiplexed systems the possibility of wavelength switching or conversion is essential, e.g., [1]. Devices with wavelength converting capabilities are therefore of great interest. It has been shown that wavelength conversion can be performed by a Distributed Bragg Reflector (DBR) laser where a part of the active section is replaced by a saturable absorber [2]. The modulation bandwidth is then limited by the carrier lifetime in the absorber section. In our case the modulation of the DBR laser is achieved by optically saturating the gain, and hence the bandwidth of the signals that can be converted is only limited by the relaxation frequency of the DBR laser. Both amplitude and frequency modulation of the wavelength converted signal can be realized by this method.

Principle of operation: A schematic of the butt-joint, flat-surface buried heterostructure DBR laser [3] is shown in Fig. 1. An amplitude modulated signal with a wavelength λ_1 is injected into the gain section of the DBR laser. The output from the DBR laser, which is oscillating at λ_2 , is then modulated due to the variation of the gain saturation. The output wavelength λ_2 can be changed by the current to the Bragg (and phase) sections. A tuning range of 4 nm towards shorter wavelengths and 18 nm towards longer wavelengths by injecting forward bias and backward bias, respectively, has previously been reported for a similar device [3].

The modulation of the gain saturation leads to a combination of amplitude modulation and frequency modulation. The FM-efficiency depends on the bias configuration and for the DBR laser used in the present experiment the FM-efficiency increases for increasing current to the gain section. Two modes of operation can then be identified:

1) Amplitude modulated output: This is illustrated in Fig. 2 where the amplitude modulated input light at 1531.5 nm increases the threshold current for the DBR-mode (1514.2 nm) from 20 to 40 mA. When the current to the gain section, I_{gain} , is set to 38.5 mA large relaxation oscillation takes place, but when I_{gain} is set to 45 mA the relaxation oscillation is reduced. The rise and fall times are short which confirms the possibility of multi-gigabit operation.

2) Frequency modulated output: In this case a high current to the gain section is used to enhance the FM-sensitivity. This configuration also leads to a high output power and therefore possibility of a high signal gain.

Experiment: In order to demonstrate the wavelength conversion a 2.5 Gbit/s amplitude modulated data stream (extinction ratio 8 dB) at a wavelength of 1531 nm and an average power of -4 dBm is injected into the DBR laser. I_{gain} and I_{Bragg} are adjusted for amplitude modulated output. Detection of the wavelength converted signal is accomplished by a commercially available 2.5 Gbit/s frontend. The BER is then measured for two wavelengths, 1514.2 nm and 1512.9 nm, and the results are shown in Fig. 3. The extinction ratio is measured to 5.3 dB and 4.5 dB, respectively. For comparison the data from the 1531.5 nm laser is detected directly and the measured BER is also shown in Fig. 3. The difference of 1-1.5 dB in sensitivity is attributed to the lower extinction ratio of the amplitude modulated wavelength converted signals. For generation of a frequency modulated wavelength converted output signal, I_{gain} is increased to 94 mA. Also in this case two wavelengths are selected for BER

measurements, 1514.1 nm and 1512.5 nm. The frequency modulated output signal from the DBR laser is demodulated by a fiber Mach-Zehnder Interferometer before detection by the frontend. In both cases the extinction ratio is measured to app. 10 dB. An output power of 9 dBm leads to a signal chip-gain of 13 dB. The BER curves are also shown in Fig.3. As can be seen, no degradation due to the wavelength conversion is observed in this case.

Conclusion: We have shown that a DBR laser can be used as a wavelength converter for multi-giga-bit/s signals and we have presented BER measurements which show penalty free wavelength conversion of 2.5 Gbit/s signals over more than 15 nm.

References:

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- [2] Kondo K. et al., IOOC'89, paper 19C4-1, Vol.2, pp 130-131, 1989
- [3] Öberg M. et al., IEEE Photonics Technol. Lett., Vol.3, No.4, pp 299-301, April 1991

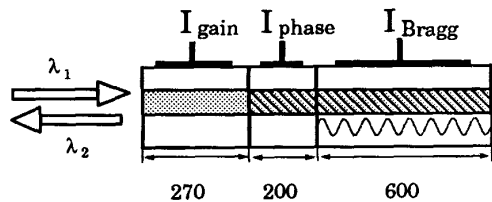


Fig. 1. Schematic diagram of the tunable laser. The length of the sections are given in μm . It is a Butt-Joint, flat-surface buried heterostructure DBR laser.

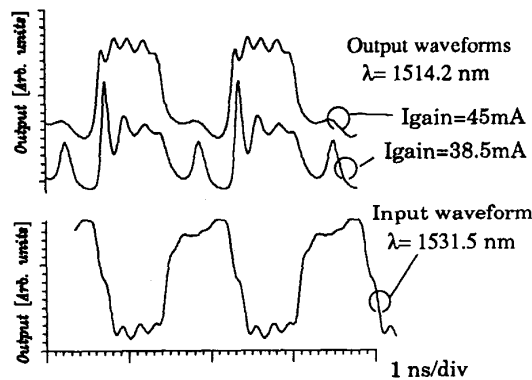


Fig. 2. A 1.2 Gbit/s 101010 input waveform from the signal laser at 1531.5 nm and the wavelength converted amplitude modulated output waveforms from the DBR laser.

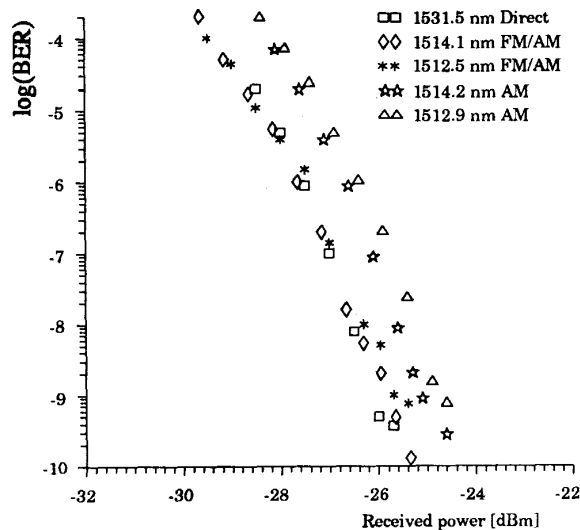


Fig. 3 Measured BER curves at 2.5 Gbit/s for amplitude modulated output at two different wavelengths, for frequency modulated output at two different wavelengths as well as for the the signal laser directly (1531.5 nm).